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Removal of Dyes from Aqueous Solution Using Low Cost Adsorbent

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ABSTRACT

Removal of basic dyes from aqueous solution was investigated using sorbent prepared from flyash, Bagasse and Rice husk and blending them with bentonite. The modifications and combinations of sorbents to form bentonite blended decolourizers enhanced sorption capacity sorbents by 10 to 20%. The effect of pH, dye concentration, sorbent dose and contact time were studied in batch experiments. The optimum pH range is 7.5 and dose required 10 g/l for maximum removal of Amaranth (AM), Crystal violet (CV) and Fluorescein (FS). The maximum removal was with FA: 69.9% AM, 63.0% FS and 69.0 % CV at dye concentration 10 gm/l, sorbent dose 10 g/l, at pH 7.5, temperature 25^0C contact time 5 h and rpm 150. The order of removal of dyes was AM>CV>FS. The order of dye removal capacities for these sorbents was found FA>BG>RH.

Keyword: dyes: Amaranth (AM), crystal violet (CV) Fluorescein (FS), adsorbent.

INTRODUCTION

The removal of dyes from industrial effluent is a major problem as Government legislation becomes more stringent. Discharge of dye bearing wastewater into natural streams from textile, paper, carpet and printing industries has created significant concern, as dyes impart toxicity and visibility[1] various techniques, such as chemical coagulation[2,3], biosortion[4], oxidation using ozone, membrane separation and adsorption have been generally employed for colour removal. Adsorption is one of the most effective physical processes for the removal of dyes from wastewaters. Most conventional adsorption systems use activated carbon as an adsorbent. Activated

carbons offer an attractive and inexpensiveoption for the removal of organic and inorganic contaminants from the water[6,7,8]. The used activated carbon is rejected and gets accumulated in many industries as solid waste. Neither all used activated carbon can be regenerated, nor it is economical to do so. Even if some specific adsorption sites get exhausted, there are other active sites on such waste activated carbon available for adsorption of other materials[9].

In the present investigation, the application of chemically treated withered Fly ash, Bagasse and Rice husk as a low cost adsorbent has been reported to be viable for removing dyes from aqueous solutions. The effect of various parameters such as contact time, initial concentration, temperature, dose and pH has been studied.

EXPERIMENTAL

DYE SOLUTION

Four aqueous solutions of 0.1,1, 10 and 20 mg/l concentrations of each of the proposed dyes Amaranth, Crystal Violet and Fluorescein were prepared by dissolving commercial grade dyes in distilled water. The dyes were obtained from CDH Pvt. Ltd., Qualigens and Thomas Baker.

PREPARATION OF SORBENTS

Natural and easily available materials like FA, BG and RH were used as sorbents for the dyes[10]. PAC was prepared from agro waste product treated with hot distilled water and dried at 100^0C, then reacting 50 g of the product so obtained with 50 ml of conc. H_2SO_4, then it was carbonized at 150^0 C for 12 hours. The sorbent was dried and crushed to increase the surface area. The particle size of 150 microns was determined with a standard test sieve. FA and BG were obtained from Chhata Sugar Mill, Mathura. RH was obtained from local factories. Adsorbents were analyzed using standard methods and their properties are presented in table 1.

TABLE1. CHARACTERISTICS OF ADSORBENT

Parameters or Characteristics	FA	RH	BG
Compositions (in %)			
Moisture	5.67	4.22	3.22
Ash	5.68	8.36	6.36
Carbon	78.9	81.73	71.73
Silica	3.02	4.64	4.65
Sodium	0.17	0.09	1.00
Potassium	0.27	0.23	0.25
Calcium	0.41	0.32	0.31
Magnesium	0.07	0.01	0.04
Phosphorous	0.06	0.03	0.04
Iron	0.32	0.12	0.14
Miscellaneous	5.34	0.25	0.25
Properties			
pH	7.34	7.83	7.84
Conductivity (µs/m)	0.75	0.62	0.64
Specific gravity	1.10	1.12	1.14
Porosity (ml/g)	0.83	0.72	0.62
Surface area (m^2/g)	328	298	208
CEC (meq/g)	0.53	Nil	Nil

BATCH STUDIES

The interaction studies were carried out in batch tests. In 6 numbers of 250 ml capacity glass bottles, 0.5 g of adsorbent was added to each of three sets, each having two bottles for different concentrations of a dye and 50 ml of the dye solution was added to

each bottle. The bottle was shaken in a reciprocating shaker at 150 rpm for 5 hours at room temperature. Then the contents were centrifuged at 2000 rpm for 10 min and the supernatant liquid was filtered using 0.45 µm member filter. The filtrate was analyzed for the dye concentration. The dye concentration in solution were measured by UV-Visible spectrophotometer. The wave length was selected so as to obtain the maximum absorbance, λ_{max}, for each dyestuff used. Double Beam UV/VIS Thermospectronic Spectrophotometer at the wave length selected for maximum absorbance of dyes, 410 nm for AM, 420 nm for CV and 480 nm for FS.

RESULT AND DISCUSSION

EFFECT OF INITIAL DYE CONCENTRATION

The effect of initial dye concentration on the sorbed amount of dyes (mg/g) is shown in table 2. Sorption capacity was found to decrease with increase in contaminant concentration. The higher uptake at lower initial concentration can be attributed to the availability of more isolated dye molecules. The removal was with FA: 69.9% AM, 69.0% CV and 63.0% FS at dye concentration 10 mg/l, sorbent dose 10 gm/l, at pH 7.5, temperature 25^{0}C, contact time 5h and rpm 150. Under the same condition RH was found to remove 68.0% AM, 62.2% CV and 48.5% FS. The order of removal of dyes was AM>CV> FS. The order of dye removal capacities for these chemical adsorbents was found FA>BG>RH. Adsorption decreased with rise in dye concentration but increased with increases in adsorbent dose.

TABLE:2 Removal % of dyes by sorbents at blended with 10% bentonite concentrations and at adsorbent dose 10 g/l, PH 7.5, temperature 25^{0}C , contact time 5h and rpm 150

Dye	Concn. mg/l	FA	BG	RH
AM	1	78.0	75.3	74.5
	5	76.4	74.5	73.6
	10	69.9	68.4	68.0
	20	67.8	67.0	66.3
CV	1	70.7	67.4	65.9
	5	69.3	65.1	64.3
	10	69.0	64.2	62.2
	20	63.2	62.4	60.1
FS	1	66.3	65.1	54.5
	5	64.3	63.5	53.0
	10	63.0	52.0	48.5
	20	51.0	50.9	45.0

EFFECT OF ADSORBENT DOSE

Batch sorption studies were performed to determine the effect of sorbent dose on dye removal table 3. The percent removal increased with increase in adsorbent dose.

EFFECT OF pH

The sorption capacity of dyes as a function of pH is shown in table 4. It is observed that the sorption of dye AM increases from 60.2% at pH 4.5 to 69.8 % at optimum pH 7.5 by FA. The dye removal is highly dependent of pH of the dye solution, which affects the surface charge of the adsorbent and degree of ionization. pH effects were found to be slightly different for different dyes. The optimum pH was 7.5 for all dyes under investigation.

TABLE 3 Removal % of dyes by sorbents blended with 10% bentonite at different sorbent doses and at dye concentration 10 mg/l, PH 7.5 temperature 25^{0}C, contact time 5h and rpm 150

Pollutant	Dose, g/l	FA	BG	RH
AM	1	65.6	63.8	61.6
	5	67.7	65.2	63.3
	10	69.2	68.2	68.0
	20	71.5	70.3	69.2
CV	1	64.7	61.5	56.8
	5	65.3	63.5	59.2
	10	69.0	64.4	62.2
	20	70.8	69.8	64.6
FS	1	55.8	48.0	43.8
	5	58.8	50.2	46.0
	10	63.4	52.7	48.0
	20	65.8	62.3	58.2

TABLE 4 Removal % dyes by sorbents blended with 10% bentonite at different pH values and at dye concentration 10 mg/l, adsorbent dose 10 g/l, temperature use 25^{0}C. Contact time 5h and rpm 150

Pollutant	PH	FA	BG	RH
AM	9.0	65.5	60.1	59.2
	7.5	69.8	68.5	68.0
	6.0	62.9	58.5	56.6
	4.5	60.2	54.4	52.2
CV	9.0	60.1	54.3	53.4
	7.5	69.2	64.8	62.9
	6.0	56.2	52.1	50.7
	4.5	53.8	50.1	48.2
FS	9.0	49.7	47.8	44.9
	7.5	63.7	52.9	48.2
	6.0	46.5	45.4	41.9
	4.5	41.7	41.5	40.6

CONCLUSION

The results of present investigation show that the waste activated carbon has good potential as adsorbent for removal of dyes. The effect of various parameters affecting the adsorption such as initial dye concentration, adsorbent dose and pH were determined. Adsorption decreases with rise in dye concentration but increases with increases in adsorbent does. The removal was with FA: 69.9% AM, 69.0% CV and 63.0% FS at dye concentration 10 gm/l, sorbent dose 10 g/l , at pH 7.5 temperature 25^{0}C, Contact time 5h and rpm 150. Under the same condition RH was found to remove 68.0% AM, 62.2% CV and 48.5% FS. The order of removal of dyes was AM >CV>FS. The order of dye removal capacities for these chemical adsorbents was FA>BG>RH. As the sorbent dose increases, percent dye removal also increases but after an optimum does of 10 g adsorbent per litre of dye solution there is no appreciable change in removal the optimum pH was 7.5 for all the dyes under investigation.

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